ASSESSMENT OF ECONOMIC DAMAGES TO THE NATURAL RESOURCES OF NEW BEDFORD HARBOR: DAMAGES TO THE COMMERCIAL LOBSTER FISHERY

Final Report

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INTRODUCTION

Because of contamination with polychlorinated biphenyls (PCBs), the Massachusetts Department of Public Health (MDPH) since 1979 has prohibited the taking of lobsters within an 18 square mile area of the Acushnet River Estuary, New Bedford Harbor, and Buzzards Bay. Closure of these grounds is one result of the natural resource damage caused by PCB contamination of the harbor, and directly affects a group of users of the estuary resource -- commercial lobstermen who previously fished in the closed area. The lost use value of the harbor as a lobster fishery is one component of the economic damages sustained by the natural resources of the New Bedford Harbor area.

Economic damages to the natural resources of the New Bedford Harbor area are measured appropriately by resource users' willingness to pay for a harbor free of PCB contamination. As a proxy measure of willingness to pay, we estimate the added cost incurred by lobstermen who were forced as a result of the closure to lobster in grounds outside the closed area. Because the added costs of this shift in use are a direct result of the PCB-induced closure, these resource users presumably would be willing to pay at least an equivalent amount for an uncontaminated New Bedford Harbor.

Our analysis indicates that the added cost the closure has imposed on 28 affected New Bedford area lobstermen is $2,594 per lobsterman each year (1985 $). For this group as a whole, the increase in annual costs is $72,632 (1985 $). Using these costs as a proxy measure of damage to the New Bedford lobster fishery, we estimate that the present value of this component of natural resource damages is $2.8 million (1985 $).

The remainder of this paper describes the adverse effects that closure of the New Bedford lobster fishery has had on area lobstermen, develops a framework for analyzing these effects, calculates the added costs incurred by lobstermen who have continued to lobster outside the closed area, and uses these added costs as a proxy measure to estimate economic damages to the New Bedford lobster fishery. We begin with a brief description of the Massachusetts inshore lobster fishery and a history of the New Bedford fishing area closure. Next, we discuss the general theory for measuring the damages from the closure, and calculate added costs to the subset of lobstermen who have remained active. We also discuss several other adverse

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effects of the closure that we cannot quantify. Our inability to quantify the damages associated with these effects leads us to underestimate total economic damages to the New Bedford lobster fishery.

CLOSURE OF THE NEW BEDFORD LOBSTER FISHERY

Overview

The Massachusetts Division of Marine Fisheries (MDMF) considers Massachusetts' inshore lobster fishery to be the most important commercial fishery within the state's territorial waters.1/ As shown in Exhibit 1, the ex-vessel value of American lobsters landed by Massachusetts' 2,436 commercial lobstermen in 1983 was $29.6 million (1983 $), representing 28 percent of the total value of the U.S. lobster catch.2/ The MDMF estimates that approximately 85 percent of the state catch (23 percent of the U.S. catch) was taken within the inshore lobster fishery.3/ The areas included in the inshore fishery are shown in Exhibit 2.

1/ Gerald M. Nash, 1983 Massachusetts Lobster Fishery Statistics, Massachusetts Division of Marine Fisheries, Technical Series No. 18, p. 1. Massachusetts' territorial waters generally are defined as waters within three miles of the state's shoreline, but also include all of Massachusetts Bay, Cape Cod Bay, and Buzzards Bay. Waters outside these areas but within 200 miles of shore are designated part of the Federal Conservation Zone (FCZ). Massachusetts' inshore lobster fishery (see Exhibit 2) includes all of the state's territorial waters, plus some areas within the FCZ. (Personal communication with Neil Churchill, March 26, 1986.)

2/ The 2,436 Massachusetts commercial license holders include: 1) 1,609 coastal lobstermen, who are permitted to lobster both in the state's territorial waters and the FCZ; 2) 267 seasonal permit holders (students permitted to lobster from June 15 to September 15); and 3) 560 off-shore fishermen, who are permitted to lobster only in the FCZ.

3/ Gerald M. Nash, 1983 Massachusetts Lobster Fishery Statistics, Massachusetts Division of Marine Fisheries, Technical Series No. 18, p. 3.

Exhibit 3 presents data on the commercial inshore lobster catch for the three Massachusetts ports of interest to this analysis -- New Bedford, Fairhaven, and Dartmouth. As the exhibit indicates, total landings for these ports declined from 1979 through 1982. This decline coincides with the official 1979 ban on the taking of lobsters in New Bedford Harbor, the grounds traditionally fished by lobstermen from these ports. Although the catch increased in 1983, the three ports' share of the total state commercial inshore catch was only two percent, compared to 3.6 percent in 1979. Based on MDMF's estimated average ex-vessel price of $2.44 per pound (1983 $), we estimate that the value of inshore lobsters landed in the ports of interest in 1983 was approximately $503 thousand (1983 $).4/

History and Extent of the Closure

PCB contamination in New Bedford Harbor first affected activity in the inshore lobster fishery in the 1970s. Scientists from Woods Hole Oceanographic Institution initially reported high levels of PCBs in the area in 1974. In 1976, the U.S. Environmental Protection Agency confirmed these findings, and the MDMF began to analyze the PCB content of tissue samples taken from area lobsters, shellfish, and finfish. On March 8, 1977, the results of this analysis led the MDPH to issue a public warning not to consume bottom feeding fish, shellfish, and eels taken from the Acushnet River Estuary or in Buzzards Bay north of a line from Ricketson's Point to Wilbur Point (see Exhibit 4, Areas I and II). On June 3, 1977, the MDPH issued a similar warning concerning consumption of lobsters. In response, New Bedford area lobstermen in August 1977 voluntarily agreed to stop fishing in Areas I and II. Two years later, on September 25, 1979, the MDPH formally prohibited the taking of lobsters in Areas I and II, and extended this prohibition to an additional area to the south (Area III, as shown in Exhibit 4). Including Area III, the MDPH action legally prohibits lobstering within an 18 square mile area of the Acushnet River Estuary, New Bedford Harbor, and Buzzards Bay.

4/ Gerald M. Nash, 1983 Massachusetts Lobster Fishery Statistics, Massachusetts Division of Marine Fisheries, Technical Series No. 18, p. 3. Note that because some inshore lobstermen do not submit catch reports (only 1,312 of 1,609 did so in 1983), the value of the catch for these three ports may be underestimated.

Effects of the Closure on Lobstermen

According to lobstermen we interviewed, the fishing area closure adversely affects their costs in several ways. For example, because the closed area includes the most accessible lobster habitat in the vicinity of New Bedford, the closure forces inshore lobstermen to fish more distant grounds. As a result, lobstermen who remain active incur increased fuel and time costs per fishing trip. Boat maintenance costs also increase as a result of greater engine wear. In addition, the higher exposure of the open grounds to harsh weather and to commercial shipping traffic increases expenses related to damage or loss of lobster traps. In light of these factors, it is evident that the fishing area closure has increased costs for inshore lobstermen based in the New Bedford area.

In addition to driving up costs, some New Bedford inshore lobstermen claim that the fishing area closure has adversely affected their revenues. For example, some lobstermen forced to deploy their gear in unfamiliar or less favorable grounds complain of reduced harvesting success per trap haul. In addition, because the waters that remain open are deeper and more influenced by weather, lobstermen claim that the number of days it is safe to venture out are limited, reducing their productive effort and ultimately their total catch. Similarly, lobstermen note that increased trap losses in the more exposed areas reduce revenues, unless the traps can be immediately replaced. By limiting productive activity or reducing yields per trap haul, these effects can diminish the revenues of lobstermen directly affected by the closure.

If the cumulative cost and revenue impacts cited above are large enough, the fishing area closure might further affect lobstermen's welfare by forcing them to give up fishing entirely. Because commercial lobstering is often as much an avocation and lifestyle as a profit-making business enterprise, there could be welfare losses as well as financial costs to quitting the lobster fishery. While these welfare losses are more difficult to measure than changes in costs and revenues, they are nonetheless a real component of the effect of the fishing area closure on New Bedford area lobstermen.

CONCEPTUAL APPROACH TO ANALYZING ECONOMIC DAMAGES TO THE NEW BEDFORD LOBSTER FISHERY

PCB contamination of New Bedford Harbor and the resulting closure of the New Bedford inshore lobster fishery have prevented productive use of this component of the harbor's natural resources. The measure of the lost use value of the lobster fishery is resource users' willingness to pay for a open fishery free of PCB contamination. A proxy measure of willingness to pay is the added costs users incur as a result of the closure. The following discussion describes a conceptual approach to measuring these costs.

It is important to note that the relevant costs for purposes of this analysis are the added costs necessary to comply with the fishing area closure, even if actual compliance is incomplete. Although none of the lobstermen that we interviewed admitted having consciously violated the closure, there have been many documented reports of lobstering inside Area III. Lobstermen who violate the ban on lobstering in New Bedford Harbor do not directly incur all of the added costs that we estimate below. However, we do not adjust our cost estimates to account for non-compliance with the closure, because we are calculating added costs only as a proxy measure of economic damages resulting from closure of the New Bedford lobster fishery. The best proxy measure of these damages -- i.e., the best approximation of society's willingness to pay for a lobster fishery free of PCB contamination -- is the added cost of complying with the closure.

Assumptions

The approach outlined below is based in part on three quite plausible assumptions about the inshore lobster fishery in the New Bedford area:

1. Changes in landings in lobsters from the inshore lobster fishery do not affect the prices paid for lobsters by households nor the prices received for lobsters by fishermen.

2. Changes in the level of activity in the inshore lobster fishery do not cause changes in the prices paid for inputs by lobster fishermen.

3. The inshore lobster fishery is in short run equilibrium, but not necessarily long run equilibrium.

The first assumption means that any decline in total landings as a result of the closure is not large enough to influence the market price. Exhibit 3 substantiates this claim, showing that New Bedford area ports account for less than four percent of the total state catch. The second assumption means that prices of inputs -- lobster pots, boats, labor, etc. -- are not influenced by the closure. The third assumption implies only a partial application of the standard bioeconomic models for fisheries, in that we do not require that lobster stock be in equilibrium with respect to the catch or that lobstermen earn revenues that exactly cover all their costs (including their opportunity costs). This assumption is justified in part by the need for a license to lobster commercially -- a barrier to entry. Typically, entry barriers prevent long run equilibrium, where revenues just equal costs, from being achieved.

Calculation of Added Costs

The cost to inshore lobstermen of complying with the closure is the difference in their net returns before and after the closure. Net returns for a lobsterman are calculated as follows:

Net Returns = Revenues - Variable Expenses - Fixed Costs

Thus, to find precisely how net returns have responded to the closure, we would need to know each lobsterman's revenues and expenses before and after the closure. The calculation of changes in revenues and expenditures, however, is complicated by the fact that lobstermen have made a variety of responses to the closure.

Interviews with lobstermen and others familiar with the closure suggest at least three kinds of responses:

1. Some lobstermen continue to fish for lobster, but do so outside the closed area, in fishing grounds further from their home ports;

2. Some lobstermen quit commercial fishing entirely; and

3. Some lobstermen have switched from lobstering to alternative fisheries.

Lobstermen in the first group have relocated the fishing effort that normally occurred in the closed area to lobster grounds in other areas of Buzzards Bay, including grounds off the Elizabeth Islands. Lobstermen in the second group have located employment outside commercial fishing, have become unemployed, or have retired, selling their boats, pots, other gear and license as they leave the fishery. Lobstermen in the third group have switched to other fisheries. Some have equipped their lobster boats for quahogging or have begun fishing for conchs, while others have sold their lobster boats and bought vessels suitable for trawling. In concept, the calculation of added costs for each group is the same. As described below, however, the problems differ in several important ways.

Group 1: Those Who Continue to Lobster

The damages to lobstermen in Group 1, those who continue lobstering outside the closed area, is measured as:

Change in Net Revenues = Increase in Variable Costs

As discussed in detail below, the increase in variable expenses is caused by having to lobster outside the closed area when the lobstermen would otherwise have fished inside the closed area. This approach assumes that lobstermen's fixed costs do not change as a result of the closure, although some lobstermen claim to have made significant capital expenditures -- for example, buying a larger boat -- in relocating their effort to more distant areas of Buzzards Bay. This approach also implicitly assumes that for the adjustments necessary to fish outside the closed area, harvest will be about the same, so that revenues are also constant. As explained below, expenses go up for this group

because of the greater time involved in getting to the fishing grounds, and because of the increased trap loss caused by fishing in more exposed waters.5/

Groups 2 and 3: Those Who Discontinue Lobstering

The calculation of changes in net revenues for lobstermen in Groups 2 and 3, those who have given up lobstering for other activities, is complicated by a number of practical limitations. First, for those who leave fishing entirely, the calculation requires information on net earnings both before and after leaving the lobster fishery. No simple model will handle the problem of earnings after leaving the fishery, because so many possibilities exist. Further, because it is likely that the lobster industry is not in long-run equilibrium (where lobstermen just cover the opportunity cost of all of their inputs, including their own time), exit from the industry may lead to a reduction in net revenues. (For example, lobstermen who when active earned returns in excess of their opportunity cost would face a decrease in net revenues if they obtained employment in an occupation that gives earnings equivalent to their opportunity cost.) The same difficulties exist for those who switch fisheries. Because the nature of the enterprise changes, reliable calculation of a change in net revenues would require information on revenues and costs for both the inshore lobster fishery and all alternative fisheries.

Limitation of the Analysis to Group 1

Because of the difficulty of accurately estimating changes in net revenues for lobstermen who leave the lobster fishery, our analysis of the costs of the fishing area closure is limited to the added costs incurred by lobstermen in Group 1 -- those who continue to lobster outside the closed area. By limiting the analysis to the added costs incurred by this subgroup of affected lobstermen, we may underestimate the true impact of the closure on lobstermen's net revenues. Consequently, the estimate of damages to the New Bedford lobster fishery developed from this

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5/ Because traps must be repaired and replaced on a regular basis, we define trap replacement costs as variable rather than fixed costs.

added cost estimate -- the proxy measure of resource users' willingness to pay for an uncontaminated lobster fishery -- may underestimate the true damages.

COST OF THE CLOSURE TO THOSE WHO CONTINUE LOBSTERING

The Potentially Affected Population

To calculate added costs for New Bedford area lobstermen who have relocated their effort to different grounds, we must estimate the number of lobstermen this group represents. First, however, we must identify the number of lobstermen who fished in the New Bedford Harbor area prior to the closure. These lobstermen are part of the population of resource users that may have been affected by closure of the New Bedford lobster fishery.

Research Method

The MDMF maintains annual records on commercial lobstermen that include information on the area fished. Unfortunately, these data do not define fishing areas at a fine enough level of detail to allow us to distinguish between lobstermen fishing in New Bedford Harbor and those fishing elsewhere in Buzzards Bay. However, the records indicate each lobsterman's port of landing. Because lobstermen fishing in the New Bedford area are likely to land at nearby ports, this information offers a reasonable starting point from which to identify the population potentially affected by the fishing area closure.

To identify commercial lobstermen who may have been affected by the closure, we asked MDMF to list all commercial lobstermen who prior to the closure reported New Bedford, Dartmouth, or Fairhaven -- the towns bordering the closed area -- as their port

of landing.6/ Because initial reports of PCB contamination might have discouraged some lobstermen from obtaining licenses in 1976 or 1977, we asked MDMF to rely on 1975 license data. Using 1975 data on commercial coastal license holders, MDMF initially identified 55 potentially affected lobstermen. Subsequently, we identified three other New Bedford area lobstermen who held licenses in 1975, and two men from MDMF's original list who claimed never to have lobstered from the three ports of interest; we modified the original list to incorporate these findings, yielding a total of 56 potentially affected lobstermen.7/ Finally, we modified the list to take into account two brothers who lobster from the same boat and a father and son who share a boat, treating these partnerships as single lobstering enterprises.8/ Exhibit 5 presents the resulting final list of 54

6/ Our request also included coastal commercial lobstermen who in 1975 reported Mattapoisett as their port of landing. We subsequently interviewed four of the 14 Mattapoisett lobstermen MDMF identified. None of these men had ever fished in the closed area or knew of any Mattapoisett lobstermen who did. Because Mattapoisett is east of Sconticut Neck (see Exhibit 4), the closed area is relatively distant and traditionally was fished by lobstermen from other towns who could reach it more easily (i.e., New Bedford, Dartmouth, and Fairhaven). Therefore, we removed Mattapoisett lobstermen from the list of those potentially affected by the closure.

7/ One area lobsterman who did not appear on MDMF's original list was added when a review of his catch reports indicated he was active in 1975. Two others who did not appear on MDMF's original list for 1975 but were identified as fishing in the New Bedford area in 1977 were added to the 1975 list when further research revealed that they held licenses in 1975. One of the two men deleted from the original list was a student in the New Bedford area but lobstered in Scituate and Boston. The other man deleted from the original list has been dead since 1976; according to his family, he never lobstered.

8/ Personal communication with Antone Everett, February 13, 1986, and with Frederick Szela Sr. and Jr., May 15, 1986.

potentially affected lobstermen (or lobstering enterprises). Our analysis of the number of lobstermen affected by the fishing area closure is based on this list.9/

To obtain information on the effect the closure has had on New Bedford area lobstermen, we interviewed 32 of the 54 men on the 1975 list; these 32 told us whether they previously had lobstered in the closed area, and described their response to the closure. (As shown in Exhibit 5, four of the remaining 22 men have refused to grant interviews, two are dead, and three cannot be located by the MDMF. We have attempted to contact the 13 others, but have been unable to do so.) Many of the 32 interviewed also agreed to provide detailed information on the nature of their lobstering activities, and 27 of the lobstermen on the 1975 list agreed to an MDMF request that they grant us access to their catch reports for the years 1973 through 1984.10/ On the basis of this information, we have characterized area lobstermen's response to the fishing area closure.

Identification of Lobstermen Who Fished In New Bedford Harbor

As noted, we interviewed 32 of the lobstermen whom we had identified as likely to have been affected by the PCB-induced closure of the New Bedford lobster fishery. As shown in Exhibit 6, six of these lobstermen reported that they never fished in the closed area, and therefore were not directly affected by the

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9/ The number of commercial coastal lobster licenses issued statewide has grown from 1,397 in 1975 to 1,609 in 1983. Therefore, our estimate of 54 potentially affected lobstermen may be conservative, in that it ignores possible growth since 1975 in the number of lobstermen operating out of the three ports of interest.

10/ Of the 32 lobstermen interviewed, 18 are among the 27 who have released catch reports to us. Exhibit 5 identifies lobstermen who granted interviews and those who released catch reports. Note that two lobstermen we interviewed (who did not release catch reports) requested that their identities remain anonymous.

closure. Most of these men did not lobster in the closed area because of special circumstances that made it easier for them to access other grounds. For example, four of the 13 Fairhaven lobstermen we interviewed claimed to operate and land in the area east of Sconticut Neck. Because these men rarely steamed around Sconticut Neck to fish in New Bedford Harbor, they were not directly affected by the closure. One of the 11 New Bedford lobstermen and one of the eight Dartmouth lobstermen we interviewed also claimed never to have lobstered in the closed area.

Assuming that the information obtained from the 32 lobstermen interviewed is representative of the behavior of the 54 potentially affected lobstermen, we can extrapolate these results across the population of lobstermen from each port to estimate the number of lobstermen who have or have not been directly affected by the closure. Exhibit 7 illustrates the calculations employed. As the exhibit shows, we estimate that seven of the 23 lobstermen who list Fairhaven as their port of landing never fished in the closed area, and therefore were not directly affected by the closure. This adjustment reduces the number of Fairhaven lobstermen on the potentially affected list to 16. Similarly, we estimate that two of the 20 New Bedford lobstermen and one of the 11 Dartmouth lobstermen we have identified never fished in the closed area, and were not directly affected by the closure. These adjustments reduce the estimated number of lobstermen affected by the closure to 18 from New Bedford and ten from Dartmouth. Summing across the three affected ports, we estimate that 44 lobstermen worked the New Bedford lobster fishery prior to the fishing ban, and therefore may have been directly affected by the closure.

Analysis of Lobstermen's Responses to the Closure

As indicated above, 26 of the lobstermen we interviewed claimed to have lobstered in New Bedford Harbor prior to the fishing area closure. These lobstermen have described to us their responses to the closure. In addition, we have catch report data for nine lobstermen we were unable to interview. To classify the effects of the closure on these nine lobstermen, we employ the following decision rules:

- Lobstermen who last reported a catch prior to 1977, the year the voluntary closure took effect, are assumed to have quit lobstering for reasons other than the closure;

- Lobstermen who last reported a catch in 1977, 1978, or 1979, the year the lobster fishery officially closed, are assumed to have quit lobstering at least in part because of the closure;

- Lobstermen who continued to lobster in 1980 and beyond are assumed to have responded to the closure by relocating to more distant fishing grounds.

Based on this approach and our interviews of the other 26 lobstermen, Exhibit 8 summarizes the response of 35 lobstermen to the fishing area closure. The discussion below describes the use of this information to classify the population of 44 potentially affected lobstermen.

Lobstermen Who Quit for Reasons Other than the Closure

Exhibit 8 indicates that eight of the lobstermen interviewed reported that they quit lobstering for reasons unrelated to the closure. In addition, one lobsterman last reported a catch prior to 1977, the year the voluntary closure took effect; as described above, we classify this individual as a member of the group that left the lobster fishery for reasons other than the closure. Therefore, nine of the 35 lobstermen for whom we have information left the fishery for reasons unrelated to the closure.

We have not reduced the population of lobstermen affected by the closure to account for those who left the fishery for other reasons, because new entries to the New Bedford area fishery are likely to have obtained licenses and replaced those who have

retired.11/ This assumption is reasonable, since the number of Massachusetts license holders remained stable from 1975 through 1980, and the number of license applicants from the New Bedford area is likely to be sufficient on average to offset ordinary turnover (as distinguished from the added retirements induced by the fishing area closure), thus maintaining the area's share of state licenses. Based on this reasoning, the only adjustment necessary for these non-closure-related retirements is to exclude the nine lobstermen from the population for whom the response to the closure is known, reducing this population from 35 to 26.

Lobstermen Who Quit
Because of the Closure

As Exhibit 8 shows, three lobstermen we interviewed claimed to have quit lobstering as a direct result of the closure. One of these men switched to alternative fisheries, while the other two ceased fishing entirely. In addition, four lobstermen we were unable to interview but for whom we have catch report data quit lobstering between 1977, the year the voluntary lobstering ban took effect, and 1979, the year the MDMF officially closed Areas I, II, and III. Since the closure was probably at least a factor in the latter four's decision to quit, we classify seven of the 26 lobstermen (27 percent) for whom we have data as members of Groups 2 or 3 -- those who switched to other fisheries or quit fishing entirely because of the closure of New Bedford Harbor. Applying this ratio to the population of 44 potentially affected lobstermen, we estimate that 12 New Bedford area lobstermen responded to the fishing area closure by leaving the lobster fishery. Because these 12 represent an incremental reduction beyond the normal turnover due to death or retirement of license holders, we would not expect ordinary recruitment of new lobstermen from the New Bedford area to replace them. Therefore, we estimate that the fishing area closure has reduced by 12 the number of inshore lobstermen that the three New Bedford area ports support.

11/ For the same reason, we have not adjusted the population of lobstermen affected by the closure to account for those who have died. We know of two lobstermen on our list of 1975 license holders who have died since the closure (see Exhibit 5).

Lobstermen Who Remain Active

As Exhibit 8 indicates, we interviewed 15 New Bedford area lobstermen who claim to have moved to new grounds and continued to lobster after the closure. From catch report data, we also have identified four others who continued to lobster in 1980 and beyond; as described above, we classify these four as having left the closed area to fish new grounds. Therefore, 19 of the 26 lobstermen (73 percent) for whom we have data remained active after the fishing area closure. Applying this percentage to the population of 44 potentially affected lobstermen, we estimate that 32 such lobstermen continued to lobster after the closure was imposed.

To develop a final estimate of the number of lobstermen in Group 1 -- those forced to change fishing grounds because of the fishing area closure -- we must determine whether any of the 32 lobstermen who remained active after the closure moved to new grounds for other reasons. All 15 of the active lobstermen we interviewed indicated that the closure was a major factor in their decisions to change fishing grounds. Two, however, stated that a perceived opportunity to increase net revenues by moving to productive and relatively unexploited grounds south of Martha's Vineyard played a role in their decision to leave New Bedford Harbor.12/ Therefore, we estimate that approximately 13 percent (two out of 15) of the 32 New Bedford area lobstermen who remained active after the closure would eventually have switched to deep-water lobstering even if the ban had not been imposed. This adjustment reduces from 32 to 28 our estimate of the number of lobstermen forced to change fishing grounds because of the fishing area closure.

Summary of the Population Analysis

Exhibit 9 contains a flow chart summarizing our analysis of the population of lobstermen potentially affected by the fishing area closure. As the exhibit shows, we estimate that 44 of 54 New Bedford area lobstermen (or lobstering enterprises) fished in

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12/ Personal communication with Thomas Egan, February 17, 1986, and with Frederick Stowell, March 14, 1986.

the New Bedford Harbor area prior to the lobstering ban. Twelve lobstermen gave up lobstering because of the closure, but 32 remained active. We assume that four of these 32 eventually would have switched to off-shore lobstering even if the ban had not been imposed, but the remaining 28 were forced to change lobstering grounds because of the fishing area closure.

Seasonal Effect of the Closure

As described above, we estimate that 28 lobstermen who once fished in the New Bedford Harbor area responded to the closure of that area by moving to more distant lobster grounds. In calculating added costs to these lobstermen, however, it is important to note that the direct effects of the closure are felt only on the occasions that lobstermen -- if there were no closure -- would set their traps in the closed area. According to those interviewed, most lobstermen would prefer to set a significant number of their traps in the closed area during the fall, winter, and spring, when the harbor area offers needed protection against the elements, and when bottom temperatures in its shallower waters are more conducive to lobstering. During the summer, however, many lobstermen would prefer to set at least half of their traps outside the closed area, because bottom temperatures close to shore become less conducive to lobstering, competition from recreational license holders increases, and worms, spider crabs, and barnacles that populate the warmer waters near shore inflict damage on traps and bait. Based on the seasonal patterns of lobstering activity described to us by lobstermen we interviewed, we estimate that the following percentages of lobstering trips each month are affected by the closure of the New Bedford lobster fishery:

- November - March: 90 percent
- April: 70 percent
- May - June: 50 percent
- July - August: 20 percent
- September - October: 50 percent

As this distribution indicates, we expect the closure to have a significant effect on commercial lobstering activity from November through March, when the weather is harshest and lobstermen strongly prefer to fish in near-shore areas. During these months, we estimate that the closure forces lobstermen to alter the location of their activity 90 percent of the time. The effect of the closure decreases somewhat in April (70 percent of trips affected) and again in May and June (50 percent of trips affected), as lobster grounds outside New Bedford Harbor gradually become more accessible and desirable to fish. During July and August, when lobstermen's desire to fish sites outside New Bedford Harbor is greatest, we estimate that the closure affects only 20 percent of all trips. The trend reverses in September and October (50 percent of trips affected), as lobstermen return their activity to near-shore areas and express a stronger preference to set their traps in New Bedford Harbor.

In order to adjust for the seasonal effects described above, we have analyzed lobstering activity for the eight lobstermen who both (1) have released catch report data to us and (2) have indicated in interviews that they responded to the closure by relocating their effort to alternative lobster grounds. Using the catch report data for these lobstermen, we calculate the average number of fishing trips per lobsterman each year since 1979, the year the New Bedford lobster fishery was officially closed.13/ In addition, we calculate the distribution of trips by month for the sample of affected lobstermen, and the average number of trips per month affected by the closure. Exhibit 10 shows the results of this analysis. As the exhibit indicates, we estimate that New Bedford lobstermen who responded to the closure by moving to alternative lobster grounds on average make 112 lobstering trips per year. Based on the average number of trips per month and the estimated percentage of these trips affected by the closure, we calculate that an average of 59 trips per lobsterman each year are affected by the closure of the New Bedford lobster fishery.

13/ MDMF catch reports did not require lobstermen to submit trip data in 1977 and 1978, the years between the voluntary closure and the official closure.

Calculation of Added Costs to Those Who Continue Lobstering

For lobstermen who have remained active in the inshore lobster fishery, the primary effect of the fishing area closure is to deny them access to their traditional fishing grounds in New Bedford Harbor, forcing them to fish the more distant waters of Buzzards Bay. As noted above, lobstermen who move to alternative, more distant grounds may face increased production costs. These added costs may be characterized as follows:

- Increased time costs;
- Increased fuel costs per voyage;
- Increased vessel maintenance costs due to increased engine wear; and
- Increased gear replacement costs due to greater exposure to harsh weather and vessel traffic.

In the following discussion, we estimate the average increase in each of these cost items.

Time Costs

The added time required to steam to lobster grounds outside the closed area imposes an opportunity cost on New Bedford area lobstermen. Exhibit 11 summarizes estimates of the additional roundtrip steaming time required to access more distant fishing grounds for the 12 affected lobstermen who provided this information. As the exhibit shows, the estimates range from no change in steaming time to an increase of four hours, reflecting differences among individuals in the distance they must travel to reach different lobstering areas. The median of the sample, however, is one hour and five minutes. Using the median as the best representation of the impact of the closure, we estimate that the increased steaming time for the typical lobsterman is one hour and five minutes.

For purposes of analysis, we value a lobsterman's time at $8.46 per hour, equivalent to the average hourly wage for captains and fishermen employed in Massachusetts' commercial fishing

industry (1985 $).14/ Exhibit 12 employs this value and the average increase in roundtrip steaming time to calculate the annual cost of increased steaming time for a typical lobsterman. (The calculation assumes that the typical lobsterman works alone, although we know that some, particularly those with larger boats, fish with a one- or two-man crew. It also ignores the opportunity cost of steaming time between traps, which some lobstermen claim has increased because traps must be set farther apart in the waters they now fish.) Employing our estimate that the fishing area closure affects 59 trips per year, the increase in time costs for the typical New Bedford area lobsterman is $541 per year (1985 $).

Fuel Costs

In addition to imposing added time costs on lobstermen, relocation of the lobstering effort to more distant lobster grounds increases average fuel consumption per trip. Exhibit 13 summarizes estimates of typical fuel consumption rates for lobster boats that we obtained in interviews with commercial boatyard operators, engine manufacturers, and lobstermen. As the exhibit indicates, the estimates range from a low of one gallon per hour of steaming time to a high of 17 gallons per hour. This broad range of estimates is to be expected, since fuel consumption varies considerably based on engine and vessel size, load, weather conditions, speed, and other factors. The median fuel consumption rate, however, is five gallons per hour, a figure representative of a mid-sized lobster boat under normal operation. We employ this figure to estimate the effect of the fishing area closure on lobstermen's fuel costs.

14/ According to Frank Cahill of the Massachusetts Division of Employment Security, the average quarterly wage for captains and fishermen in the state's commercial fishing industry (3Q 1985) is $4,399. Based on a standard 13 week quarter and 40 hour work week, we estimate the average hourly wage to be $8.46 (1985 $). Because employment in other sectors of the commercial fishing industry is a likely alternative use of time currently spent lobstering, this figure provides a reasonable estimate of the opportunity cost of time spent lobstering.

Exhibit 14 uses our estimates of the median increase in steaming time and the median vessel fuel consumption rate to calculate the average increase in fuel consumption for New Bedford area lobstermen. Based on our estimates, the fishing area closure has increased fuel consumption for the average lobsterman by slightly more than five gallons per trip. On an annual basis, the average increase in individual fuel consumption is 320 gallons. At an average retail price of $0.88 per gallon of fuel, this increase translates to added costs per lobsterman of $281 per year (1985 $).15/

Vessel Maintenance Costs

Because New Bedford area lobstermen now must steam farther to reach their lobster grounds, their engine maintenance requirements are greater. Exhibit 15 summarizes estimates of engine maintenance costs provided by commercial boatyards and engine manufacturers. The estimates range from $0.14 to $1.25 per hour of steaming time (1985 $), reflecting differences in engine size, type, and use. The median estimate, however, is $0.59 per hour (1985 $). We employ this figure to calculate the likely increase in vessel maintenance costs attributable to closure of the New Bedford lobster fishery.

Exhibit 16 illustrates calculation of the estimated increase in vessel maintenance costs. Based on the increase in steaming time, added maintenance costs per lobsterman are $0.64 per trip (1985 $). Annually, added costs per lobsterman are approximately $38 (1985 $).

15/ Lobstermen in the New Bedford area employ both gasoline- and diesel-powered boats. According to Jerry Wheeler of Seafood Cooperative, a commercial boatyard in Fairhaven, the average price of diesel fuel sold by the boatyard in 1985 was $0.89 per gallon (1985 $). This price includes neither federal nor state excise taxes on fuel, from which commercial fishermen are exempt. Data from the Massachusetts Office of Energy Resources indicates that the statewide average retail price of self-serve regular leaded gasoline in 1985, excluding excise taxes, was $0.87 per gallon (1985 $). Our calculation of fuel costs therefore employs an average price of $0.88 per gallon (1985 $).

Gear Replacement Costs

Aside from his boat, traps are a lobsterman's most important investment. Coastal lobstermen in the New Bedford area fish with conventional wooden or wire lobster pots, set individually or on a trawl line (usually five or ten pots to a line). However, the number of traps fished by coastal lobstermen may vary significantly. To estimate the average number of traps fished by lobstermen who have remained active since closure of the New Bedford lobster fishery, we have analyzed catch report data for the same 8 lobstermen upon whom we based our annual trip analysis. As Exhibit 17 indicates, these lobstermen on average have fished 232 traps per year since 1978, the year following the voluntary ban on lobstering in New Bedford Harbor. This figure is slightly lower than the 1983 statewide average of approximately 250 traps.16/ Based on an average value of $32.50 for trap, warp, and buoy, 232 traps represent an investment of $7,540 for the average New Bedford area lobsterman (1985 $).17/

Lobstermen we interviewed generally claimed that the waters in which they now set their traps are more exposed to harsh weather and vessel traffic, increasing equipment damage and loss beyond that experienced in New Bedford Harbor. A particularly severe problem associated with fishing in more open waters is the danger of damage by commercial fishing boats, barges, and other commercial shipping traffic, which can easily drag away traps or inadvertantly cut trap lines. Exhibit 18 summarizes information on increased trap losses for the nine lobstermen who provided this information. As the exhibit indicates, all nine lobstermen stated that trap losses are greater outside the closed area than they were inside that area. The exhibit also indicates that there is great variation in lobstermen's perceptions of the difference in trap loss between the closed and open areas, with

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16/ Gerald M. Nash, 1983 Massachusetts Lobster Fishery Statistics, Massachusetts Division of Marine Fisheries, Technical Series No. 18, p. 6.

17/ We obtained the estimated cost of a trap, warp, and buoy from the MDMF. (Personal communication with Charles Anderson, MDMF, April 29, 1986.)

the estimates of increased trap loss ranging from 10 percent to 62 percent.18/ The median of the sample, however, is 23 percent; we use this figure as the basis for our added cost calculation.

Exhibit 19 illustrates the calculations employed to estimate the cost of the increased trap loss attributable to the fishing area closure. Assuming the average lobsterman fishes 232 pots (the average for the lobstermen analyzed), a 23 percent increase in equipment damage represents an incremental loss of approximately 53 traps per year. Using the estimated unit cost of $32.50 for trap, warp, and buoy, the increased gear replacement cost for the average lobsterman equals $1,734 per year (1985 $).

Total Costs

Exhibit 20 summarizes the estimates of added costs developed above and calculates the average annual cost increase across the entire population of affected lobstermen. As the exhibit shows, we estimate that a lobsterman who moved to new lobster grounds as a result of the fishing area closure has incurred added costs of $2,594 per year (1985 $). Because the closure had this impact on 28 lobstermen, we estimate that the total annual added cost to lobstering operations resulting from the closure is $72,632 (1985 $).

PRESENT VALUE OF DAMAGES TO THE NEW BEDFORD LOBSTER FISHERY

In the preceding analysis, we estimate the annual cost of the fishing area closure to commercial inshore lobstermen who are forced to move to more distant fishing grounds. As indicated above, these costs provide a proxy measure of economic damage to

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18/ The broad variation in lobstermen's perceptions of increased trap loss is probably in part due to the intermittent nature of trap damage. For example, one lobsterman who has moved offshore for reasons other than the closure stated that his trap losses had been similar to those he incurred inshore, except for two occasions when he lost 300 and 620 traps to commercial fishing vessels. (Personal communication with Frederick Stowell, March 14, 1986.)

the New Bedford lobster fishery. Based on this proxy measure, we estimate that annual damages to the fishery equal $72,632 (1985 $).

To estimate total damages to the New Bedford lobster fishery, we must calculate the present value of annual damages across the period of time that New Bedford Harbor is closed to commercial lobstering. Because our annual damage estimates are expressed in 1985 dollars, we calculate their present value in 1985. Therefore, annual costs incurred prior to 1985 are compounded to their 1985 present value, and annual costs incurred after 1985 are discounted to their 1985 present value.19/

For purposes of analysis, we calculate the present value of damages incurred from 1980, the first full year following the official closure of the New Bedford lobster fishery, through the year 2085, 100 years into the future. This analysis assumes that Areas I, II, and III will remain closed to lobstering through 2085. The analysis employs a real discount rate of three percent.

Exhibit 21 presents the results of this analysis. As the exhibit shows, we estimate that the present value of damages to the New Bedford lobster fishery is $2.8 million (1985 $).

UNDERESTIMATION OF TOTAL DAMAGES

As a proxy measure of damages to the natural resources of the New Bedford lobster fishery, we calculate only the higher costs incurred by those lobstermen who continue to fish for lobster. As previously noted, we do not attempt to measure the decrease in net revenues incurred by lobstermen who have been forced to quit lobstering because of the closure. By ignoring the adverse effect of the lobster fishery closure on ths group,

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19/ The analysis is based on the real cost of labor, fuel, engine maintenance, and lobster traps in 1985. Implicit in this analysis is the assumption that rates of inflation (or deflation) in the cost of these inputs will equal rates of inflation (or deflation) in the general economy. Violations of this assumption will result in minor over- or underestimation of the present value of natural resource damages.

we may underestimate the true impact of the closure on lobstermen's net revenues. In addition, the added costs calculated for Group 1 do not take into account any increase in fixed costs (such as the costs associated with purchase of a larger boat), the opportunity cost of increased steaming time for crew members on boats with a crew, or the increased costs associated with setting traps over a broader area. Consequently, the estimate of damages to the New Bedford lobster fishery developed from this added cost estimate -- the proxy measure of resource users' willingness to pay for a restored lobster fishery -- may underestimate the true damages.

Our analysis also ignores several other adverse effects of the closure. For example, we do not analyze the increased risk to lobstermen who now must venture further from shore to reach their traps. Presumably, these lobstermen would be willing to pay a premium to avoid these risks and once again have access to the safer waters of New Bedford Harbor. In addition, the shifting of lobster traps from the closed area to an outside area already harvested by others could potentially reduce the abundance of lobsters in areas that remain open to fishing. Such a reduction in abundance would mean reduced revenues for those lobstermen who were not directly affected by the closure, and in the long-run could detrimentally affect the productivity of the entire fishery. Measuring this effect would require substantially more biological and technical information about the lobster fishery than is presently available. In addition, we have not analyzed the influence of displaced lobstermen on the abundance of species in other fisheries. By not attempting to measure these effects, we have an estimate of the damages incurred by society that is inherently conservative.

CONCLUSION

A ban on the harvest of lobsters in the Acushnet River Estuary, New Bedford Harbor, and portions of Buzzards Bay was one of the first actions taken in response to the discovery of PCB contamination in the harbor area. Closure of the New Bedford lobster fishery has forced local lobstermen out of their accustomed fishing grounds, into other grounds, into other fisheries, and occasionally out of fishing entirely. The lost value of the harbor in its use as a lobster fishery is one component of the economic damages sustained by the natural resources of the New Bedford Harbor area.

As described above, an appropriate measure of economic damage to the natural resources of the New Bedford Harbor area is resource users' willingness to pay for equivalent resources free of PCB contamination. As a proxy measure of willingness to pay, we have estimated the added cost incurred by lobstermen who have continued to lobster in grounds outside the closed area. Because the added costs of this continuing use are a direct result of the PCB-induced closure, resource users presumably would be willing to pay at least an equivalent amount for an uncontaminated New Bedford Harbor.

Our analysis indicates that the added cost to New Bedford area lobstermen forced to relocate their fishing effort outside the closed area is $2,594 per lobsterman each year (1985 $). For the group of 28 lobstermen affected in this way, the increase in annual costs is $72,632 (1985 $). Using these costs as a proxy measure of damage to the New Bedford lobster fishery, we estimate that the present value of damages is $2.8 million (1985 $).

Exhibit 1

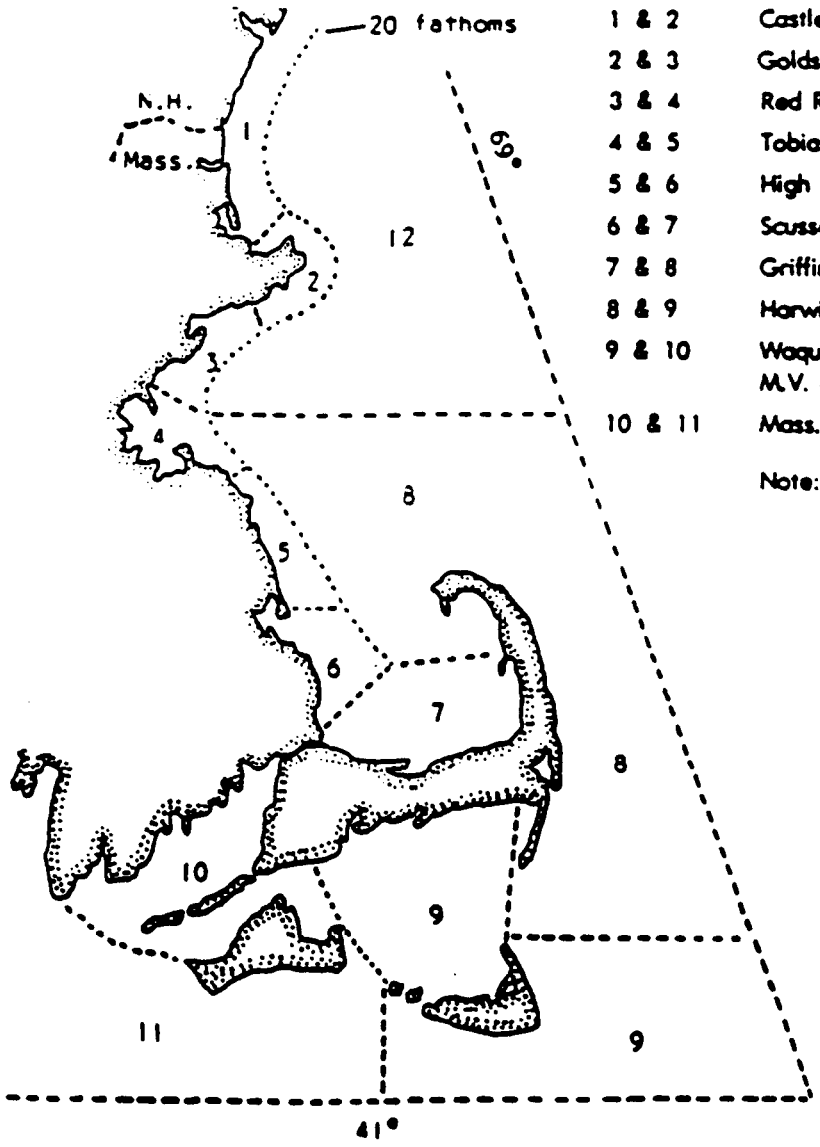
MASSACHUSETTS AND NATIONAL COMMERCIAL LOBSTER AND FISHING STATISTICS FOR 1983

	United States	Massachusetts	Massachusetts as a Percent of U.S.
Lobster Catch (000 pounds)	44,206	12,137	27 %
Lobster Value ($000 1983)	106,766	29,614	28
Total Fish Catch (000 pounds)	6,438,724	376,917	6
Total Fish Value ($000 1983)	2,355,446	244,936	10
Lobster as Percent of Fish Catch	1 %	3 %	NA
Lobster as Percent of Fish Value	5 %	12 %	NA

Sources: "Fisheries of the United States, 1983", National Marine Fisheries Service; and "1983 Massachusetts Lobster Fishery Statistics", Massachusetts Division of Marine Fisheries.

Exhibit 2

MDMF LOBSTER AREAS



Between Areas	BOUNDARIES
1 & 2	Castle Neck, Ipswich
2 & 3	Goldsmith Point, Manchester
3 & 4	Red Rock, Lynn
4 & 5	Tobias Ledge (Spindle), Scituate
5 & 6	High Pines Ledge, Plymouth
6 & 7	Scussett Beach, Sandwich
7 & 8	Griffin Island, Wellfleet
8 & 9	Harwich/Chatham Line
9 & 10	Waquoit Bay, Falmouth - Cape Poge, M.V. - Muskeget Island
10 & 11	Mass./R.I. Line - Gay Head

Note: The seaward boundary of Areas 1 through 7 is the 20 Fathom line.

Source: Massachusetts Division of Marine Fisheries

Exhibit 3

INSHORE COMMERCIAL LOBSTER LANDINGS FOR
NEW BEDFORD, FAIRHAVEN, AND DARTMOUTH:
1979 - 1983

		Catch (pounds)	Percent of State Catch
1979 -	New Bedford	138,997	1.9 %
	Dartmouth	7,740	0.1
	Fairhaven	113,768	1.6
	Total *	260,505	3.6 %
1980 -	New Bedford	104,339	1.3 %
	Dartmouth	11,020	0.1
	Fairhaven	83,223	1.0
	Total	198,582	2.4 %
1981 -	New Bedford	88,003	1.0 %
	Dartmouth	2,537	0.0
	Fairhaven	76,829	0.9
	Total	167,369	1.9 %
1982 -	New Bedford	65,002	0.7 %
	Dartmouth	4,159	0.0
	Fairhaven	95,105	1.0
	Total	164,266	1.8 %
1983 -	New Bedford	106,972	1.1 %
	Dartmouth	8,473	0.1
	Fairhaven	90,583	0.9
	Total	206,028	2.0 %

* Totals may not equal sums due to rounding error.

Source: MDMF catch reports and IEc analysis.

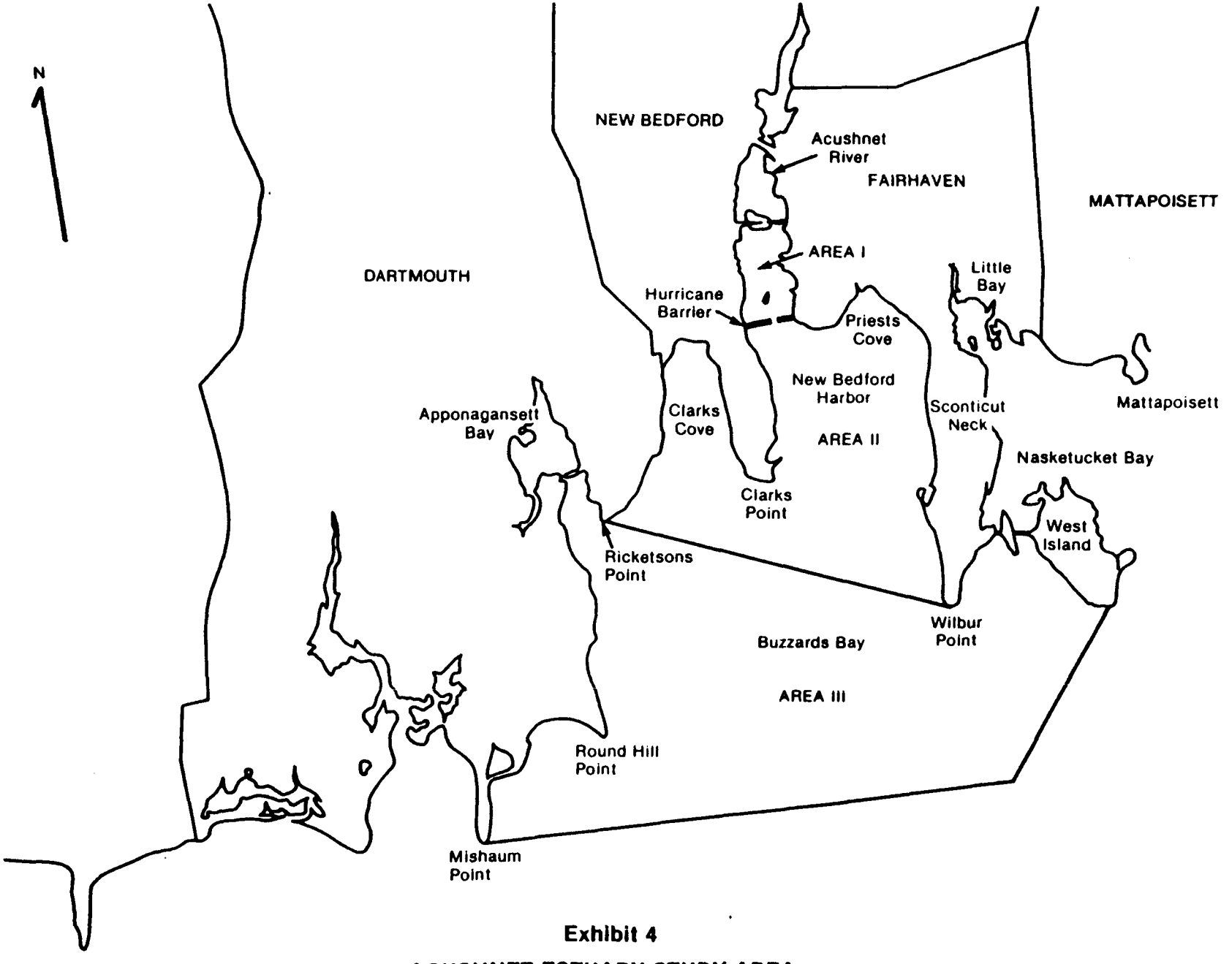


Exhibit 4

ACUSHNET ESTUARY STUDY AREA

Exhibit 5

LOBSTERMEN FROM NEW BEDFORD, DARTMOUTH, OR FAIRHAVEN
WHO HELD COMMERCIAL INSHORE LICENSES IN 1975 *

Name	Address		Port	Released Catch Reports	Interview Status **
Baroe, Ronald	61 Roger Street	S. Dartmouth	Dartmouth		Interviewed
Dias, Arthur	20 Highland Street	S. Dartmouth	Dartmouth	Yes	Interviewed
Egan, Thomas	62 George Street	S. Dartmouth	Dartmouth	Yes	Interviewed
Ferguson, Daniel	137 Berkley Street	N. Dartmouth	Dartmouth		
Fryar, Scott	P.O. Box P-152	S. Dartmouth	Dartmouth		Refused Interview
Gosselin, Warren	57 Merrimac Street	New Bedford	Dartmouth	Yes	
Lemberg, Arthur	85 Cogeshall Street	New Bedford	Dartmouth	Yes	Interviewed
Manley, Allen	1116 Fisher Road	Dartmouth	Dartmouth	Yes	Interviewed
Mello, Antone	10 Walsh Street	S. Dartmouth	Dartmouth		Interviewed
Perras, Ronald	45 Chace Road	E. Freetown	Dartmouth		Refused Interview
Russell, Richard	20 Little River Road	S. Dartmouth	Dartmouth	Yes	Interviewed
Amaral, Joseph	46 Briercliffe Road	Fairhaven	Fairhaven		Interviewed
Arruda, Joseph	4 Lincoln Drive	Fairhaven	Fairhaven		Refused Interview
Boza, Stephen	220 Mt. Pleasant Street	New Bedford	Fairhaven	Yes	Interviewed
Cook, Robert	233 Aquidneck Road	New Bedford	Fairhaven		Interviewed
Dixon, Walter	28 Mendell Road	Rochester	Fairhaven	Yes	Interviewed
Down East Co.	44 Dartmouth Street	New Bedford	Fairhaven		
Everett, Antone ++	41 Gelette Road	Fairhaven	Fairhaven	Yes	Interviewed
Everett, John ++	185 Sconticut Neck Road	Fairhaven	Fairhaven		See Antone Everett
Farias, Antone	12 Orchard Street	Fairhaven	Fairhaven	Yes	Interviewed
Fernandes, Joseph	54 Yale Street	Fairhaven	Fairhaven	Yes	Interviewed
Fitzgerald, Michael	141 Balsam Street	Fairhaven	Fairhaven		
Harrison, Walter	97 Farmfield Street	Fairhaven	Fairhaven		Interviewed
Hassey, Ernest	1049 Tucker Road	N. Dartmouth	Fairhaven	Yes	Refused Interview
Horsley, Robert	1 Bates Road	Fairhaven	Fairhaven		
Laviolette, Charles	33 Nakata Avenue	Fairhaven	Fairhaven		MDMF Can't Locate
Lawrence, Robert	16 Samoset Avenue	Fairhaven	Fairhaven	Yes	Interviewed
Little, Manville	16 Littleneck Road	Fairhaven	Fairhaven		
Massaitis, Joseph	644 Pearl Street	Brockton	Fairhaven	Yes	
Mitchell, Rosinos	25 Charity Stevens Lane	Fairhaven	Fairhaven		MDMF Can't Locate
Pauline, John	20 Bonney Street	Fairhaven	Fairhaven	Yes	Interviewed
Phaneuf, Robert	34 Bay Street	Fairhaven	Fairhaven		Dead
Quintin, Stephen	107 Oak Grove Lane	Fairhaven	Fairhaven	Yes	
Sakwa, Robert	61 Farmfield Street	Fairhaven	Fairhaven	Yes	Interviewed
Wlodyka, Walter	108 Cedar Street	Fairhaven	Fairhaven		Interviewed

Exhibit 5
(continued)
LOBSTERMEN FROM NEW BEDFORD, DARTMOUTH, OR FAIRHAVEN
WHO HELD COMMERCIAL INSHORE LICENSES IN 1975 *

Name	Address		Port	Reports	Interview Status **
Amaral, Manuel	27 Morton Avenue	Fairhaven	New Bedford	Yes	
Baron, Stanley Jr.	?	N. Dartmouth	New Bedford		Interviewed
Camara, John	30 Welcome Street	New Bedford	New Bedford	Yes	
Connor, Charles	63 Buttonwood Road	S. Dartmouth	New Bedford	Yes	Interviewed
Cusson, Leo	221 Hathaway Road	Acushnet	New Bedford		Interviewed
Estrella, James	175 Acushnet Avenue	New Bedford	New Bedford		MDMF Can't Locate
Ferreira, Joseph	5 Winthrop Street	New Bedford	New Bedford	Yes	Interviewed
Foster, Edward	419 North Street	New Bedford	New Bedford	Yes	
Francis, Stephen	216 Dartmouth Street	New Bedford	New Bedford		Dead
Garcia, Richard	34 Westwood Drive	N. Dartmouth	New Bedford	Yes	
Herrington, Ronald	P.O. Box B-972	New Bedford	New Bedford	Yes	
Lynam, Gordon	60 So. Second Street, Apt 6F	New Bedford	New Bedford		
Mello, Alvaro	125 Winterville Road	New Bedford	New Bedford	Yes	Interviewed
Perentz, Richard	168 Arnold Street	New Bedford	New Bedford		Interviewed
Perry, Arnold	90 Woodlawn Street	New Bedford	New Bedford	Yes	Interviewed
Ponte, John	253 Green Street	Fairhaven	New Bedford		
Sansoucy, Arthur	144 Mouse Mill Road	Westport	New Bedford		Interviewed
Stowell, Frederick	447 Smith Neck Road	S. Dartmouth	New Bedford		Interviewed
Szela, Frederick Jr. +	171 Bay View	New Bedford	New Bedford		Interviewed
Szela, Frederick Sr. +	171 Bay View	New Bedford	New Bedford		See F. Szela Jr.
Vital, Thomas	786 Fisher Road	N. Dartmouth	New Bedford	Yes	Interviewed

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* Data as of 16 May 1986.

** In addition to those indicated, we have interviewed two lobstermen who requested that their identities remain confidential.

\+ Frederick Szela Jr. & Sr. fish from the same boat and for purposes of this analysis are treated as a single entity. We have interviewed both men, but in the text count these interviews as a single interview.

++ Antone and John Everett fish from the same boat and for purposes of this analysis are treated as a single entity. We have interviewed Antone and received catch reports from both John and Antone. In the text, we count this information as a single interview and a single set of catch reports.

Exhibit 6

IDENTIFICATION OF LOBSTERMEN WHO PREVIOUSLY LOBSTERED IN THE CLOSED AREA

Lobsterman	Port	Previously Lobstered in Closed Area
Anonymous	Dartmouth	Yes
Ronald Baroa	Dartmouth	Yes
Arthur Dias	Dartmouth	Yes
Thomas Egan	Dartmouth	Yes
Arthur Lemberg	Dartmouth	Yes
Allen Manley	Dartmouth	No
Antone Mello	Dartmouth	Yes
Richard Russell	Dartmouth	Yes
Stanley Baron Jr.	New Bedford	Yes
Charles Connor	New Bedford	Yes
Leo Cusson	New Bedford	Yes
Joseph Ferreira	New Bedford	Yes
Alvaro Mello	New Bedford	Yes
Richard Perentz	New Bedford	Yes
Arnold Perry	New Bedford	Yes
Arthur Sansoucy	New Bedford	No
Frederick Stowell	New Bedford	Yes
Frederick Szela Jr. & Sr.	New Bedford	Yes
Thomas Vital	New Bedford	Yes
Joseph Amaral	Fairhaven	No
Anonymous	Fairhaven	Yes
Stephen Boza	Fairhaven	Yes
Robert Cook	Fairhaven	No
Walter Dixon	Fairhaven	Yes
John and Antone Everett	Fairhaven	No
Antone Farias	Fairhaven	Yes
Joseph Fernandes	Fairhaven	Yes
Walter Harrison	Fairhaven	Yes
Robert Lawrence	Fairhaven	No
John Pauline	Fairhaven	Yes
Robert Sakwa	Fairhaven	Yes
Walter Wlodyka	Fairhaven	Yes

Source: Interviews with New Bedford area lobstermen.

Exhibit 7

CALCULATION OF THE NUMBER OF LOBSTERMEN WHO PREVIOUSLY FISHED IN NEW BEDFORD HARBOR

Fairhaven

Total Lobstermen: 23

Lobstermen Interviewed: 13

Fished in New Bedford Harbor: 9
Fished outside New Bedford Harbor: 4

Estimate of total number of lobstermen who fished in New Bedford Harbor:

$9/13 \times 23 = 15.9 \sim 16$

Estimate of total number of lobstermen who fished outside New Bedford Harbor:

$4/13 \times 23 = 7.1 \sim 7$

New Bedford

Total Lobstermen: 20

Lobstermen Interviewed: 11

Fished in New Bedford Harbor: 10
Fished outside New Bedford Harbor: 1

Estimate of total number of lobstermen who fished in New Bedford Harbor:

$10/11 \times 20 = 18.2 \sim 18$

Estimate of total number of lobstermen who fished outside New Bedford Harbor:

$1/11 \times 20 = 1.8 \sim 2$

Exhibit 7

CALCULATION OF THE NUMBER OF LOBSTERMEN
WHO PREVIOUSLY FISHED IN NEW BEDFORD HARBOR
(continued)

Dartmouth

Total Lobstermen: 11

Lobstermen Interviewed: 8

Fished in New Bedford Harbor: 7
Fished outside New Bedford Harbor: 1

Estimate of total number of lobstermen who fished in New Bedford Harbor:

7/8 x 11 = 9.6 ~ 10

Estimate of total number of lobstermen who fished outside New Bedford Harbor:

1/8 x 11 = 1.4 ~ 1

Total for Affected Ports

Fished in New Bedford Harbor:

16	Fairhaven
18	New Bedford
10	Dartmouth
44	Total

Fished outside New Bedford Harbor:

7	Fairhaven
2	New Bedford
1	Dartmouth
10	Total

Source: Interviews with area lobstermen and IEc analysis.

Exhibit 8

RESPONSE OF NEW BEDFORD AREA LOBSTERMEN TO THE FISHNG AREA CLOSURE

	Response			Basis for Classification	
Lobsterman	Continued Lobstering	Quit Due to Closure	Quit For Other Reasons	Interview	Catch Report
Anonymous	X			X	
Anonymous		X		X	
Manual Amaral	X				X
Ronald Baroa			X	X	
Stanley Baron, Jr.	X			X	
Stephen Boza	X			X	X
John Camara		X			X
Charles Connor	X			X	X
Leo Cusson			X	X	
Arthur Dias			X	X	X
Walter Dixon	X			X	X
Thomas Egan	X			X	X
Antone Farias	X			X	X
Joseph Fernandes	X			X	X
Joseph Ferreira	X			X	X
Edward Foster	X				X
Richard Garcia		X			X
Warren Gosselin			X		X
Walter Harrison			X	X	
Ernest Hassey	X				X
Ronald Herrington		X			X
Arthur Lemberg			X	X	X
Joseph Massaitis	X				X
Alvaro Mello		X		X	X
Antone Mello			X	X	
John Pauline			X	X	X
Richard Perentz	X			X	
Arnold Perry		X		X	X
Stephen Quintin		X			X
Richard Russell			X	X	X
Robert Sakwa	X			X	X
Frederick Stowell	X			X	
F. Szela Jr. & Sr.	X			X	
Thomas Vital	X			X	X
Walter Wlodyka	X			X	

Source: Interviews with New Bedford area lobstermen and Massachusetts Division of Marine Fisheries catch reports.

Exhibit 9

ESTIMATED EFFECT OF THE CLOSURE ON 56 LOBSTERMEN FROM NEW BEDFORD, FAIRHAVEN, AND DARTMOUTH

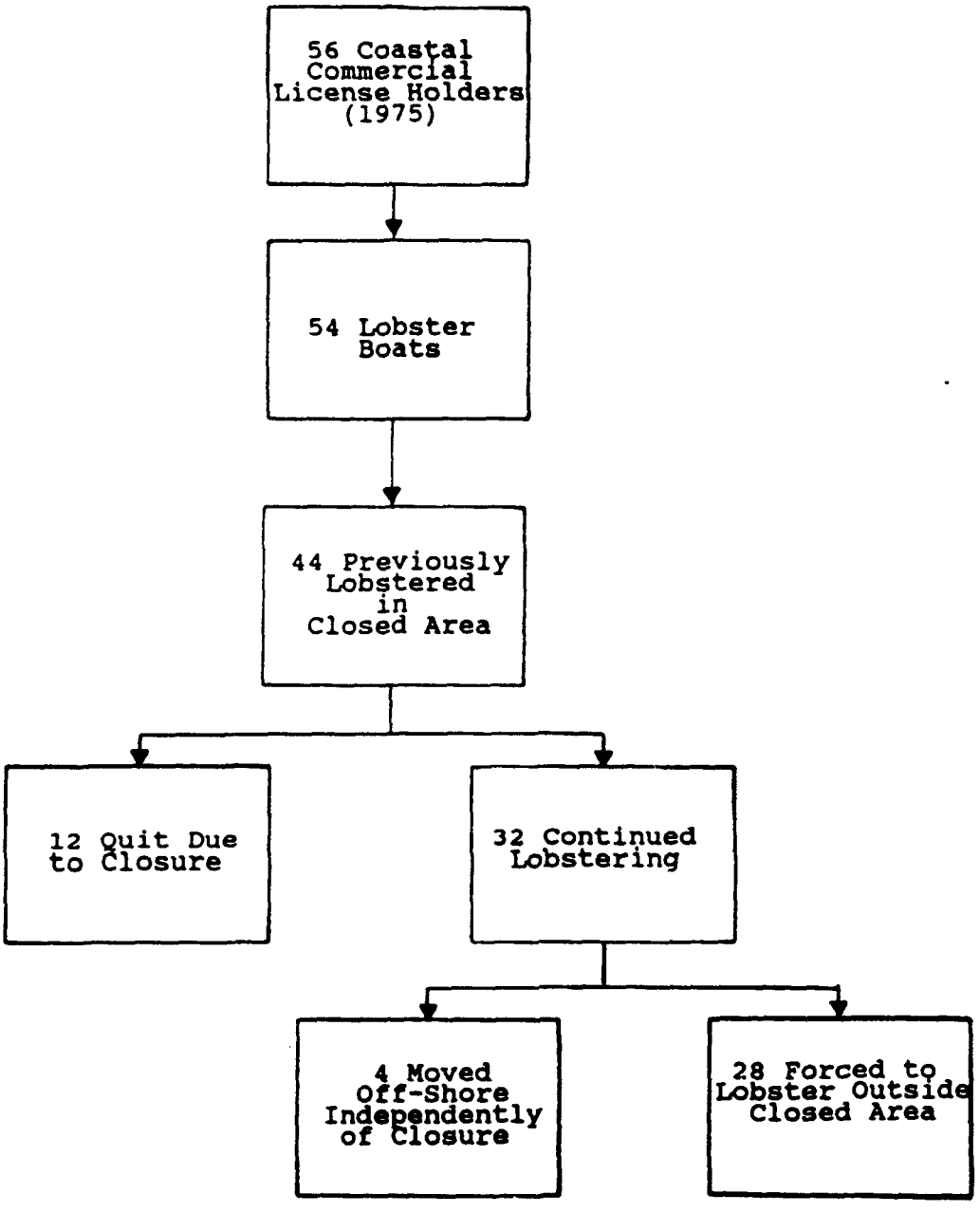

Exhibit 10

CALCULATION OF THE AVERAGE NUMBER OF TRIPS PER YEAR AFFECTED BY THE CLOSURE

Month	Average Number of Trips per Year						Overall Average	Percent of Trips Affected by Closure	Average Number of Trips Affected by Closure
	1979	1980	1981	1982	1983	1984			
January	2.6	6.8	0.7	1.0	3.5	3.5	3.0	90	2.7
February	0.3	2.0	1.7	1.3	2.8	4.8	2.1	90	1.9
March	2.9	3.2	9.2	6.4	5.8	4.8	5.4	90	4.9
April	17.6	15.6	18.0	15.0	11.6	12.5	15.0	70	10.5
May	19.0	18.4	19.3	20.9	14.4	14.5	17.7	50	8.9
June	21.3	15.0	18.7	16.3	18.0	16.2	17.6	50	8.8
July	24.9	21.0	19.5	19.4	15.0	16.0	19.3	20	3.9
August	10.0	12.4	10.8	14.9	9.1	14.2	11.9	20	2.4
September	3.3	3.2	3.2	4.6	2.4	3.0	3.3	50	1.7
October	6.7	2.6	3.3	5.3	1.9	3.5	3.9	50	2.0
November	10.7	6.0	6.3	7.0	3.3	5.0	6.4	90	5.8
December	9.1	5.2	7.0	6.3	4.1	7.0	6.5	90	5.9
Annual Average	128.3	111.4	117.7	118.3	91.8	105.0	112.1		59.4

Source: MDMF catch reports and IEc calculations

Exhibit 11

ESTIMATED INCREASE IN ROUNDTRIP STEAMING TIME
DUE TO CLOSURE OF THE NEW BEDFORD LOBSTER FISHERY

Lobsterman	Increase in Roundtrip Steaming Time
Anonymous	1 hour
Stanley Baron, Jr.	1 hour, 15 minutes
Stephen Boza	1 hour, 20 minutes
Charles Connor	1 hour, 10 minutes
Walter Dixon	3 hours
Antone Farias	No Change
Joseph Fernandes	1 hour
Joseph Ferreira	No Change
Richard Perentz	4 hours
Robert Sakwa	1 hour
Frederick Szela, Jr. & Sr.	3 hours
Walter Wlodyka	50 minutes

Median Value: 1 hour, 5 minutes

Source: Interviews with New Bedford area lobstermen.

Exhibit 12

AVERAGE INCREASE IN ANNUAL TIME COSTS
(1985 $)

Data & Assumptions:

Median increased steaming time	=	65 minutes per trip
Average number of affected trips	=	59 trips per year
Time value	=	$8.46 per hour

Cost Calculations:

$/yr = minutes/trip x trips/yr x $/hr x hr/minute

$/yr = 65 minutes/trip x 59 trips/yr x $8.46/hr
x 1 hr/60 minutes

= $540.74

Source: IEc calculations

Exhibit 13

ESTIMATED FUEL CONSUMPTION RATES FOR LOBSTER BOATS

Source	Estimated Fuel Consumption per Hour of Steaming Time (gal/hr)	Engine Type
Seafood Cooperative Fairhaven, MA	5	Detroit 671 Diesel
D.N. Kelley Fairhaven, MA	5	Diesel
Linberg Marine Fairhaven, MA	3.5	Diesel
Southwest Machinery Hopkinton, MA	3	Diesel
Northeast Ford Engines Gloucester, MA	5	100 hp Diesel
Cummins Engine Columbus, IN	7 15	150 hp Diesel 350 hp Diesel
Anonymous, Fairhaven lobsterman	3	NA
Stephen Boza, Fairhaven lobsterman	6	Diesel
Charles Connor, New Bedford lobsterman	7	Diesel
Walter Dixon, Fairhaven lobsterman	5	Diesel
Tom Egan, Dartmouth lobsterman	6	Diesel
Joseph Fernandes, Fairhaven lobsterman	3	Gasoline outboard
Joseph Ferreira New Bedford lobsterman	1	Gasoline outboard
Richard Perentz New Bedford lobsterman	17	Diesel

Exhibit 13

ESTIMATED FUEL CONSUMPTION RATES FOR LOBSTER BOATS
(continued)

Source	Estimated Fuel Consumption per Hour of Steaming Time (gal/hr)	Engine Type
Richard Russell, Dartmouth lobsterman	3.5	Gasoline outboard
Robert Sakwa, Fairhaven lobsterman	1.75	Diesel
Frederick Szela, Sr. New Bedford lobsterman	1.5 6	Diesel Gasoline

Median Value: 5 gallons per hour

Source: Interviews with commercial boatyard operators, engine manufacturers, and New Bedford area lobstermen.

Exhibit 14

AVERAGE INCREASE IN ANNUAL FUEL COSTS
(1985 $)

Data & Assumptions:

Median increased steaming time	=	65 minutes per trip
Median estimated fuel consumption	=	5 gallons per hour
Average number of affected trips	=	59 trips per year
Average fuel cost	=	$0.88 per gallon

Cost Calculations:

$/yr = minutes/trip x trips/yr x gal/hr x $/gal x hr/minute

$/yr = 65 minutes/trip x 59 trips/yr x 5 gal/hr x $0.88/gal x 1 hr/60 minutes

= $281.23

Source: IEc calculations

Exhibit 15

ESTIMATED ENGINE MAINTENANCE COSTS FOR LOBSTER BOATS
(1985 $)

Source	Estimated Maintenance Cost per Hour of Use	Engine Type
Seafood Cooperative Fairhaven, MA	$0.67	Detroit 671 Diesel
D.N. Kelley Fairhaven, MA	$0.50	Diesel
Linberg Marine Fairhaven, MA	$1.25	Diesel
Southwest Machinery Hopkinton, MA	$0.20	3208 Diesel
Northeast Ford Engines Gloucester, MA	$0.68	135 hp Diesel
Cummins Engine Columbus, IN	$0.14 $0.20	350 hp Diesel 150 hp Diesel
Gifford Marine Dartmouth, MA	$1.25	Gasoline outboard

Median Value: $0.59 per hour of use

Source: Interviews with commercial boatyard operators and engine manufacturers.

Exhibit 16

AVERAGE INCREASE IN ANNUAL VESSEL MAINTENANCE COSTS
(1985 $)

Data & Assumptions:

Median increased steaming time = 65 minutes per trip
Average number of affected trips = 59 trips per year
Median engine maintenance cost = $0.59 per hr of steaming time

Cost Calculations:

$/yr = minutes/trip x trips/yr x $/hr x hr/minute

$/yr = 65 minute/trip x 59 trips/yr x $0.59/hr x 1 hr/60 minute

= $37.71

Source: IEc calculations

Exhibit 17

CALCULATION OF THE AVERAGE NUMBER OF TRAPS FISHED BY LOBSTERMEN IN GROUP 1

Lobsterman	1978	1979	1980	1981	1982	1983	1984	Average Traps Fished Per Year
Boza, S.	278	329	447	375	400	304	342	354
Connor, C.	291	294	338	360	367	200	NA	308
Dixon, W.	176	240	310	267	238	DL	20	209
Farias, A.	250	200	250	200	142	170	200	202
Fernandes, J.	NA	NA	NA	NA	58	25	40	41
Ferreira, J.	160	180	NA	180	200	167	204	182
Sakwa, R.	169	189	179	181	213	129	189	178
Vital, T.	300	186	244	306	301	273	296	272
Average	232	231	295	267	240	181	184	232

NA: Catch report not available
DL: Did not lobster

Note: Entries coded NA or DL are ignored in calculating the average number of traps fished.

Source: MDMF catch reports and IEc calculations.

Exhibit 18

ESTIMATED INCREASE IN ANNUAL TRAP LOSS
DUE TO CLOSURE OF THE NEW BEDFORD LOBSTER FISHERY

Lobsterman	Average Traps Fished 1978-1984	Average Annual Trap Loss Pre-Closure	Average Annual Trap Loss After-Closure	Change in Percentage of Traps Lost
Anonymous	175	10 - 15 (7%)	120 (69%)	+ 62%
Charles Connor	308	15 (5%)	75 - 100 (28%)	+ 23%
Stanley Baron, Jr.	NA	NA (15%-20%)	NA (25%-30%)	+ 10%
Stephen Boza	354	15 - 20 (5%)	100 (28%)	+ 23%
Antone Farias	202	Few * (9%)	75 - 100 (43%)	+ 34% *
Joseph Fernandes	41	5 (12%)	20 (49%)	+ 37%
Joseph Ferreira	182	NA (20%)	NA (25%-35%)	+ 10%
Robert Sakwa	178	15 - 20 (10%)	30 - 40 (20%)	+ 10%
Frederick Szela, Sr.	110	5 - 10 (7%)	30 - 40 (32%)	+ 25%

Median Value: 23% increase in annual trap loss

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* Mr. Farias could not provide a specific estimate of trap loss in the closed area, stating only that he lost "very few". For purposes of analysis, we assign him a pre-closure loss rate of 9 percent, equal to the median reported by the other lobstermen.

Source: MDMF catch reports and interviews with New Bedford area lobstermen.

Exhibit 19

AVERAGE INCREASE IN ANNUAL GEAR REPLACEMENT COSTS
(1985 $)

Data & Assumptions:

Average traps fished per lobsterman	=	232 traps per year
Average trap cost	=	$32.50 per trap
Median increase in trap loss	=	23 percent per year

Cost Calculations:

$/yr = traps/yr x $/trap x median increase in trap loss

$/yr = 232 traps/yr x $32.50/trap x .23

= $1,734.20

Source: IEc calculations

Exhibit 20

TOTAL ADDED COSTS PER YEAR TO LOBSTERMEN IN GROUP 1
(1985 $)

Estimated Added Costs Per Lobsterman Per Year:

Time	$ 541
Fuel	281
Engine Maintenance	38
Gear Replacement	1,734
Total	$2,594

Calculation of Added Costs Per Year Across Total Population:

Total $/yr = $/lobsterman/yr x affected lobstermen

= $2,594/lobsterman x 28 lobstermen

= $72,632

Source: IEc calculations

Exhibit 21

PRESENT VALUE OF ESTIMATED DAMAGES TO
THE NEW BEDFORD LOBSTER FISHERY
(1985 $)

Given:

Annual Damages	=	$72,632
Discount Rate	=	3 percent
Duration of Past Damages (1980-1985)	=	6 years
Duration of Future Damages (1986-2085)	=	100 years

Present Value of Past Damages:

$$PV = \sum_{t=0}^{5} 72,632\ (1 + .03)^{t}$$

$$= \$469,813.54$$

Present Value of Future Damages:

$$PV = \sum_{t=1}^{100} \frac{72,632}{(1 + .03)^{t}}$$

$$= \$2,295,091.69$$

Present Value of Total Damages:

$$PV = \$469,813.54 + \$2,295,091.69$$

$$= \$2,764,905.23$$

Source: IEc calculations